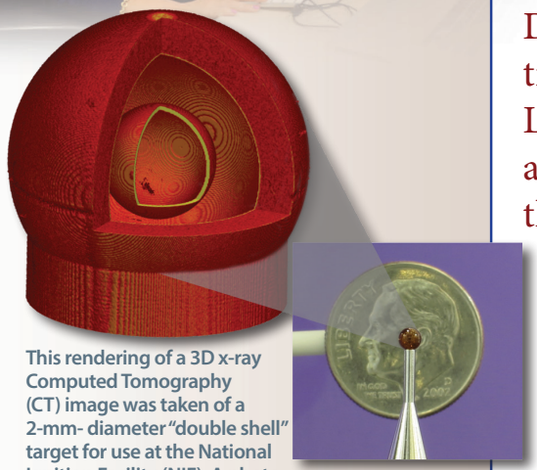
Nondestructive Characterization

Lawrence Livermore National Laboratory

Do you have an assembly, waste drum, or even human tissue that needs to be studied nondestructively? Lawrence Livermore can help you understand objects smaller than a poppy seed or as large as a cargo container, made of the lightest aerogels to the densest, heaviest elements.

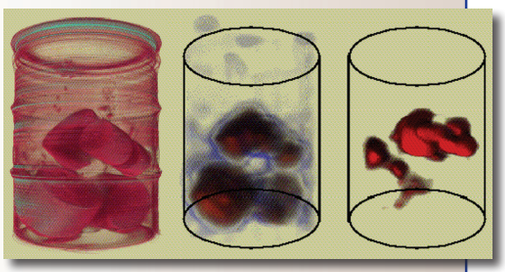


This rendering of a 3D x-ray Computed Tomography (CT) image was taken of a 2-mm- diameter "double shell" target for use at the National Ignition Facility (NIF). A photo of the target is on the right.

LLNL is a U.S. Department of Energy laboratory that has become a leader in Nondestructive Characterization (NDC). We research, design, and build novel systems and methods for government, industry, and academia to understand and help solve their NDC problems.

This is how we approach Nondestructive Characterization:

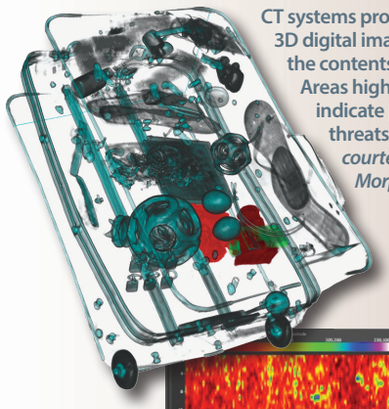
Does this item have anomolies?
We ***INSPECT*** materials and objects for surface flaws or internal defects using electromagnetic waves (x-rays, gamma rays, infrared, visible, mm-wave, radar), sound waves (ultrasonics, acoustic, modal analysis), and/or particles (protons, neutrons), from small (~µm) devices/materials through luggage to bridge decks.



An R&D100 award-winning technique precisely and accurately measures radioactivity inside 55-gallon waste barrels by combining (left to right) x-ray, gamma-ray, and single-photon emission CT data.

What is this item's physical makeup?
We ***CHARACTERIZE*** the properties (e.g., density, elemental composition, and grain structures) of materials and objects for diagnostic purposes, including waste drums, airline baggage, human breast, aerogels, National Ignition Facility (NIF) targets, and military, commercial, and homemade explosives.

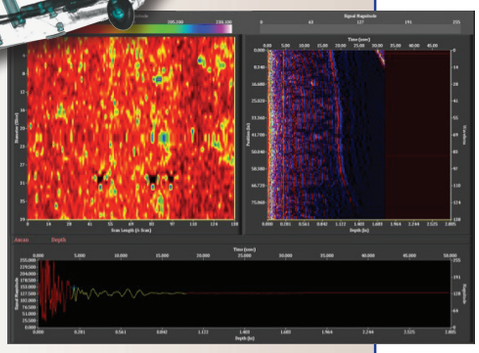
Was this item built as designed?
We ***EVALUATE*** objects and compare them to their design to determine if they meet specifications such as additively manufactured parts, turbine blades, and integrated circuits. We also convert NDC data to "as built" vs. "as designed" models for better understanding between simulated and experimental data.



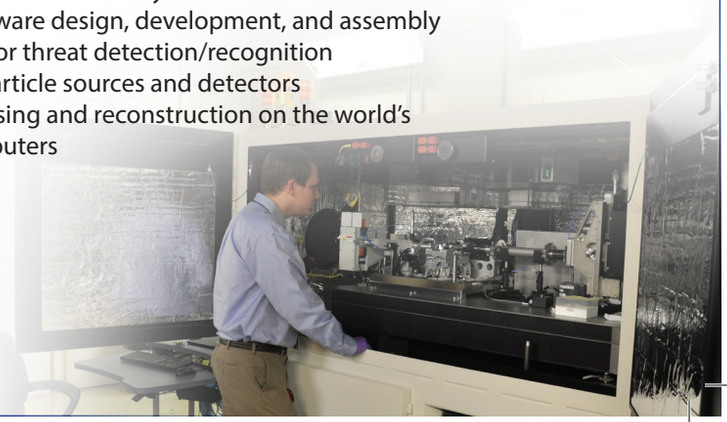
CT systems produce 2D and 3D digital images showing the contents of luggage. Areas highlighted in red indicate potential threats. (*Photo courtesy of Safran Morpho.*)

We have expertise in:

- NDC research and techniques (e.g., x-ray, acoustic, thermal, mm- wave, optical, and neutrons)
- Modeling and simulation (straight ray, e.g., HADES, and Monte Carlo, e.g., MCNP, GEANT, COMSOL, and Imagine3D)
- Data analysis, signal and image processing
- Image reconstruction algorithms and software
- Statistical and model-based analysis
- Systems and hardware design, development, and assembly
- Automatic defect or threat detection/recognition
- Novel x-ray and particle sources and detectors
- Fast image processing and reconstruction on the world's largest supercomputers



Ultrasonic surface scan shows details of a composite warhead.



Facilities and Technologies

We are ISO 9000 certified and maintain numerous dedicated NDC facilities on site, including:

- LLNL-built 125- to 225-keV micro-focus radiography/CT system with 2- to 35-cm field of view, 1 to 20x magnification, and 20- to 400-µm spatial resolution
- LLNL-built 80- to 450-keV radiography/CT system with 0.5- to 35-cm field of view, 1 to 2x magnification, and 0.1- to 400-µm spatial resolution
- LLNL-built CoLOSSIS 9-MeV radiography/CT system with 35-cm field of view and 400-µm spatial resolution
- Xradia MicroXCT-200 50- to 150-keV microscale radiography system with 1- to 6-mm field of view, 4 to 40x magnification, and 1- to 6-µm spatial resolution
- Xradia UltraXRM-L200 8.04-keV nanoscale radiography system with 65- to 16-µm field of view, 200 and 800x magnification, and 150- and 50-nm spatial resolution
- LLNL's high-energy (6/9 MeV) linear- and area-array radiography detectors can image objects up to 10 m and as small as 30 cm at 8-mm and 200-µm spatial resolution, respectively
- Access to Advanced Light Source x-ray beamline at Berkeley and McClelland Nuclear Research Center neutron imaging facility
- LLNL's explosive facilities to NDC explosive from a few grams up to 160 kg
- Category 3 nuclear facility to NDC Special Nuclear Materials (SNM)
- Panametrics 5-axis UT immersion scanning system, with adjustable working volume to 90 cm x 45 cm x 130 cm

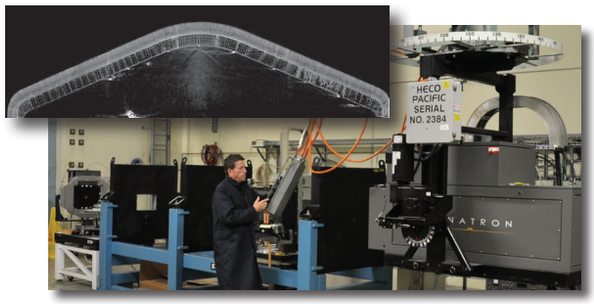
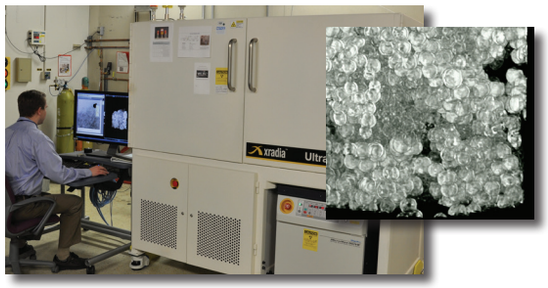
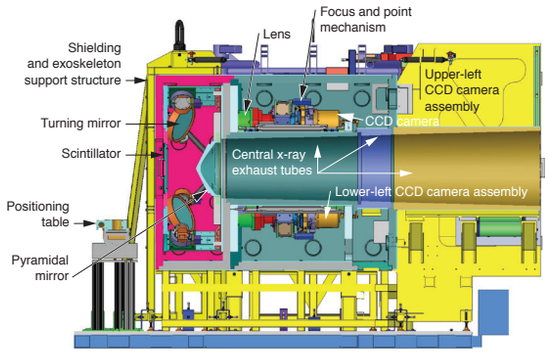


Photo of the 6- and 9-MeV radiography/CT facility. (Inset) 9-MeV CT cross section of a NASA composite ablator 2.6 m o.d.



50- to150-nm spatial resolution CT system (UltraXRM). (Inset) 3D rendered image of copper foam (many 1 µm hollow 100-nm wall thickness copper beads).



A cutaway view of the LLNL-built Confined Large Optical Scintillator Screen and Imaging System (CoLOSSIS), which collects 3D digital x-ray images of industrial objects and test components.

Sponsors

DOE/NNSA/EM
Department of Homeland Security
  Transportation Security Administration
  Domestic Nuclear Detection Office
Department of Defense
  Defense Threat Research Agency
Ford, GM, Chrysler
Tyndall Air Force Base
NASA

Academic Alliances

Purdue University
University of California, Berkeley
University of California, Davis
University of California, San Diego
Northeastern University
University of Notre Dame
Stanford University
Tufts University
University of Bologna

Capability Leaders

Harry E. Martz, Jr., Ph.D. **925-423-4269** **martz2@llnl.gov**

Harry is the Director for the Nondestructive Characterization Institute, which has pioneered ways to use x rays and other forms of radiation and particles (protons and neutrons) for noninvasive imaging of everything from warhead components to bridge decks to breast tumors. He holds a Ph.D. in Nuclear Physics/Chemistry from Florida State University. He received an R&D 100 Award for radiation waste barrel assay. He was a member of several National Academies of Science (NAS) committees and currently chairs an NAS committee on airport passenger screening systems.

Stephen Azevedo, Ph.D. **925-422-8538** **azevedo3@llnl.gov**

Steve handles R&D projects related to aviation and cargo security, high-energy-density physics, acoustics, radar remote sensing, and particle and radiation detection. He has earned four R&D 100 awards. He led the micropower impulse radar (MIR) project and is a former director of the Center for Advanced Signal and Image Sciences. He holds a Ph.D. in Electronics Engineering and Computer Science from the University of California, Davis.

Karl Fisher, Ph.D. **925-423-0132** **fisher34@llnl.gov**

Karl is the group leader for Nondestructive Evaluation, which provides advanced NDC technical solutions for numerous laboratory programs and work for others. He is a member of the Acoustical Society of America and a Senior Member of IEEE. He holds a Ph.D. in Mechanical Engineering from the Georgia Institute of Technology.

LAWRENCE LIVERMORE NATIONAL LABORATORY
LLNL-BR-659238